Symposium on
Technologies for Protecting Aquatic Organisms from Cooling Water Intake Structures
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Innovative Cooling System for Heat and Flow Reduction at Brayton Point Station

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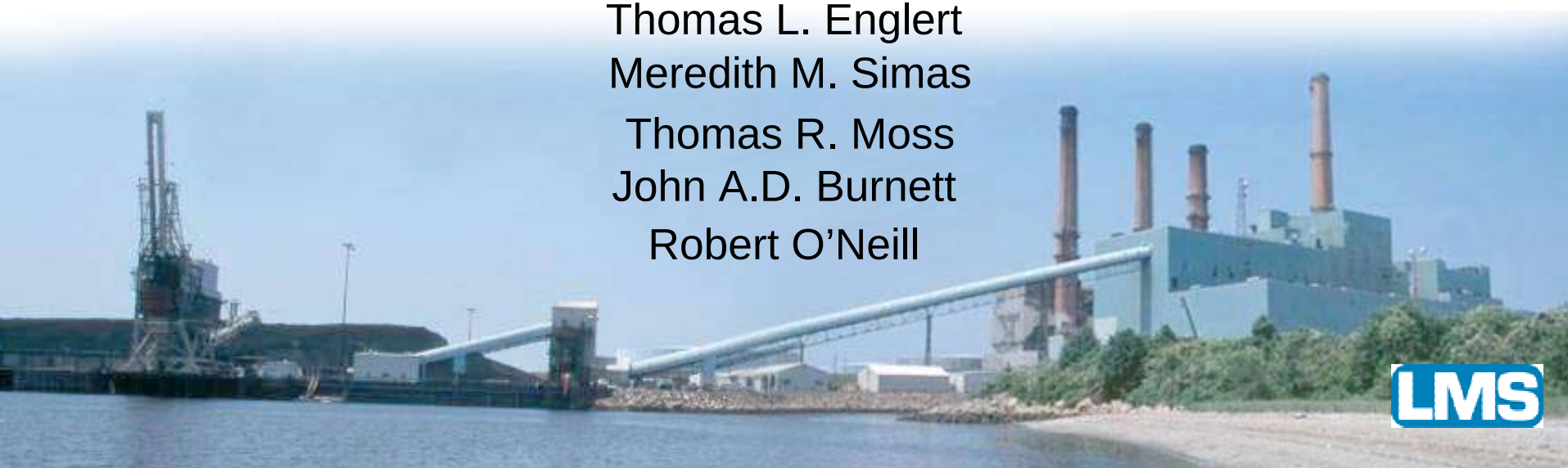


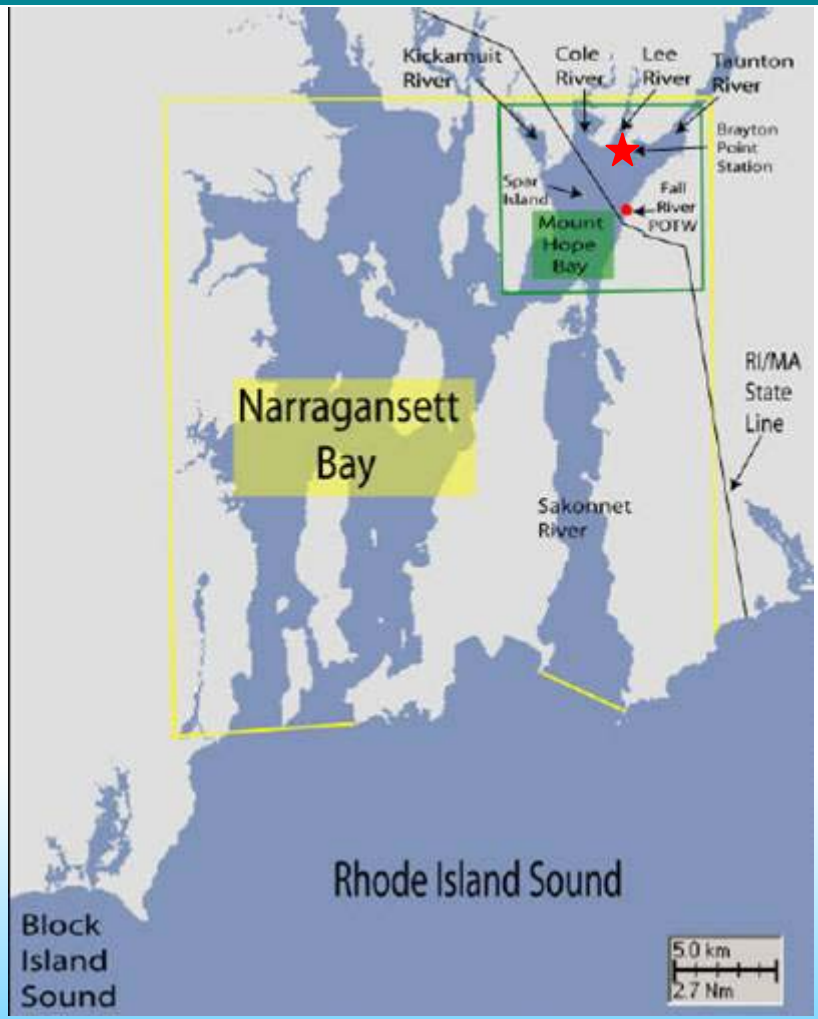
An *Innovative* Cooling System

Enhanced Multi-Mode Cooling (EMM)

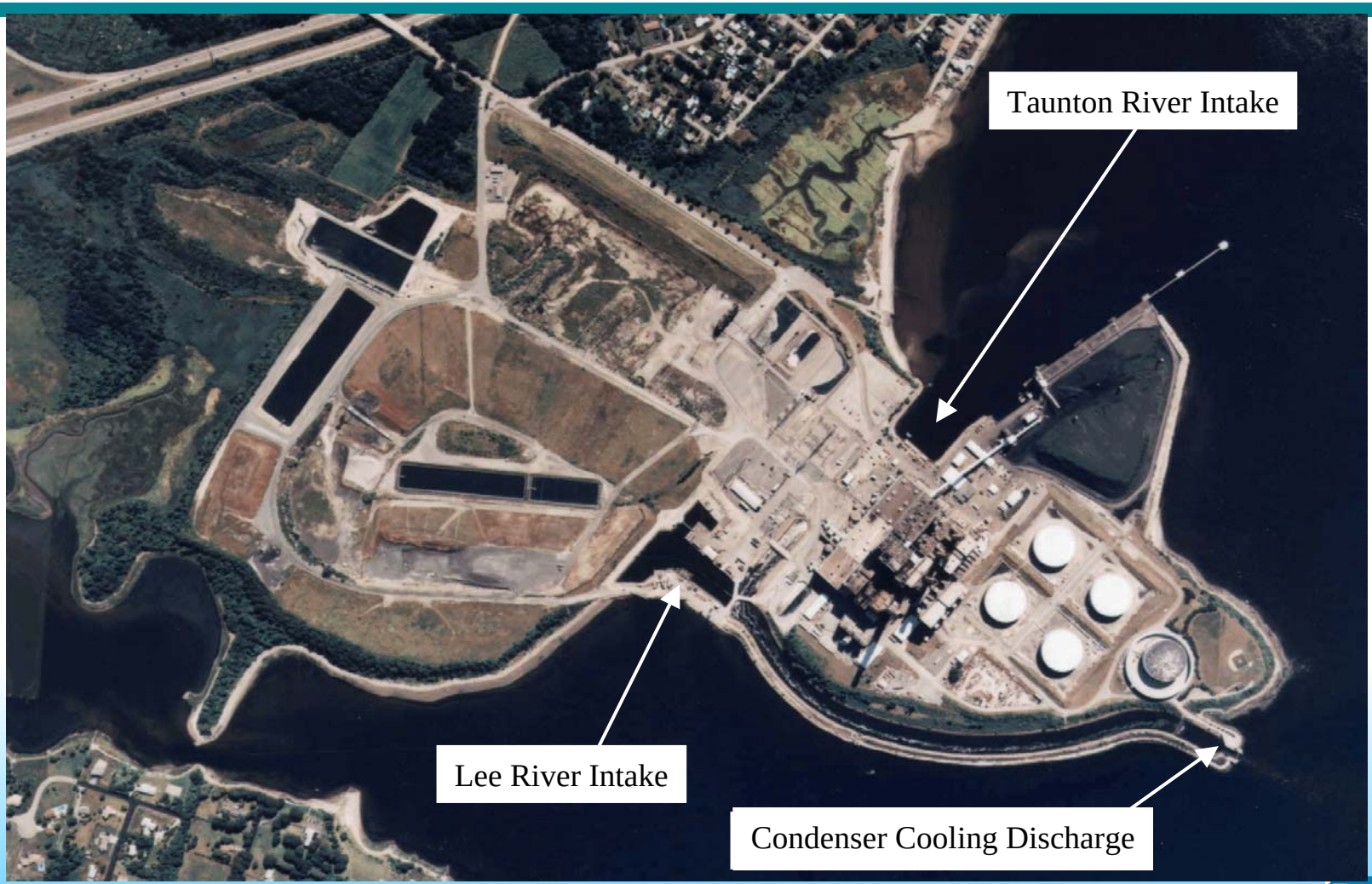
Presentation Overview

- Existing System
- Alternatives Evaluated
- Describe the EMM
- Biological Benefits
- Costs of technologies
- Cost/Benefit Comparison

Brayton Point Generating Station



Brayton Point Station Aerial View

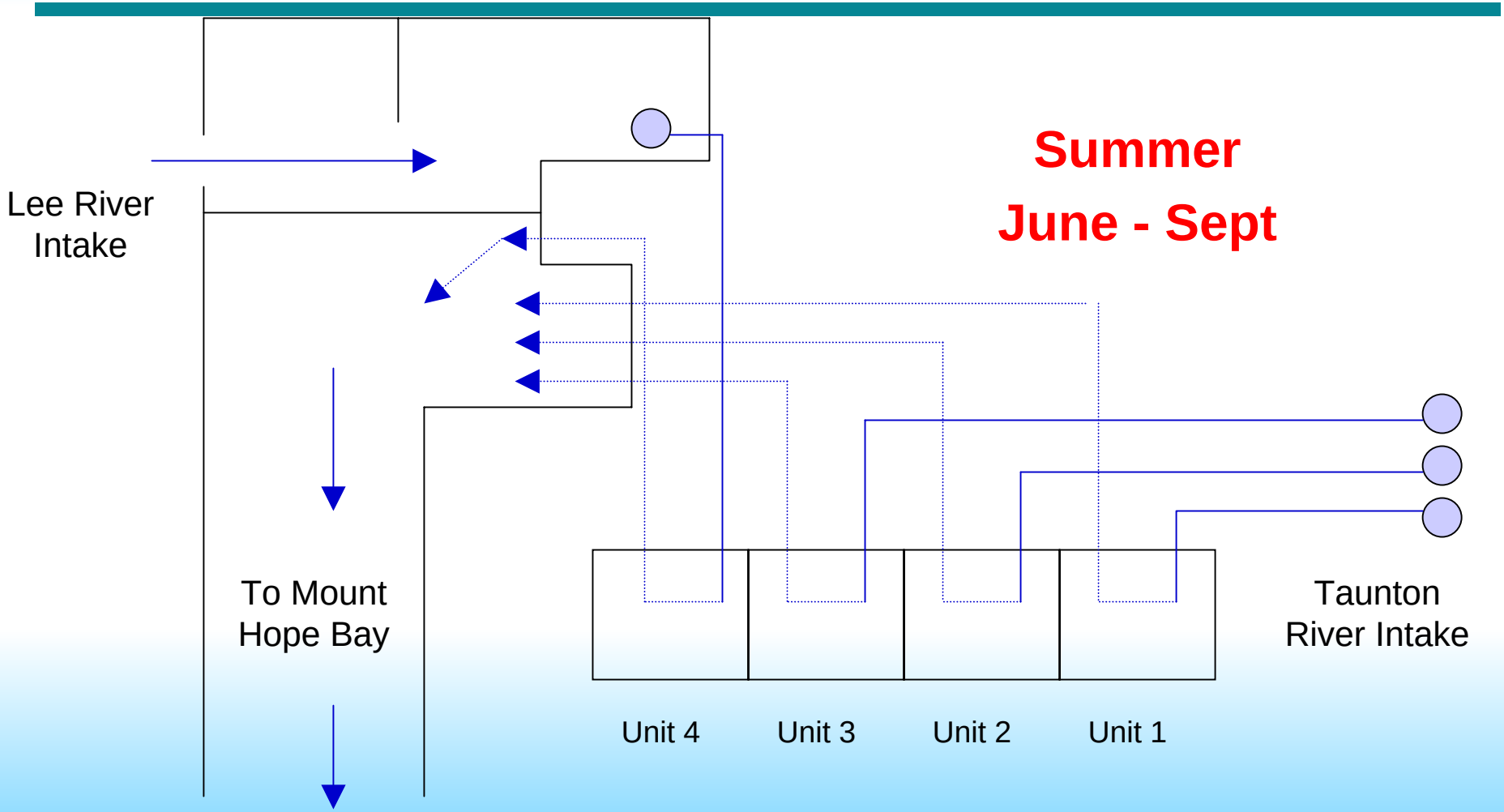


Station Operations

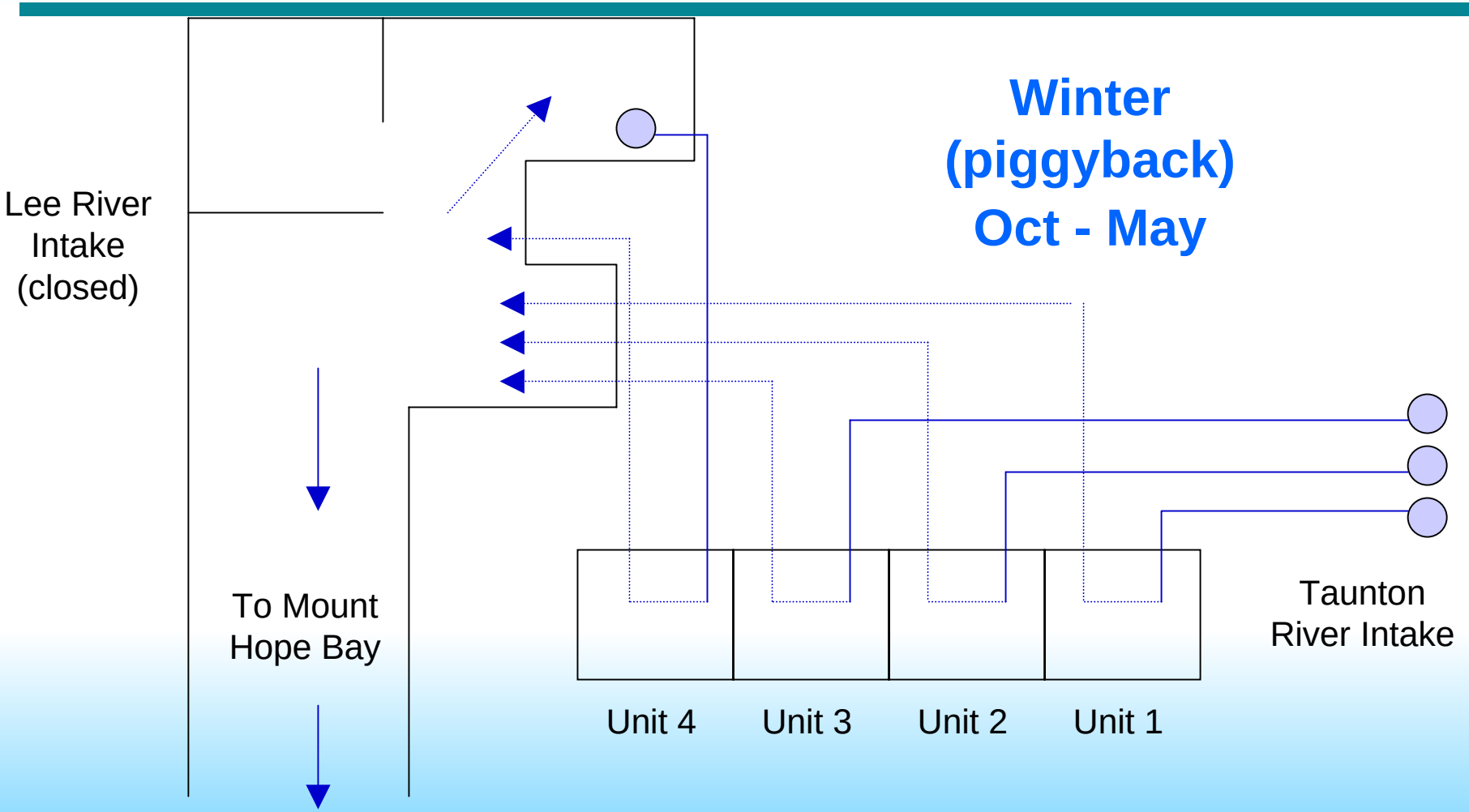
	MW Capacity	Condenser Duty MBTU/hr	Flow (Gal/min)	Max Design Temperature Rise (^{o}F)	Commercial Start-up
Unit 1	250	1,098	180,000	12.2	Aug 1963
Unit 2	250	1,098	180,000	12.2	July 1964
Unit 3	650	2,590	280,000	18.5	July 1969
Unit 4	450	2,340	260,000	18.0	Dec 1974
Service Water	-	232.7	31,000	15.0	-
Combined	1,600	7,360	931,000	15.8	-

- Units 1, 2 & 3 – Coal-fired
- Unit 4 – Gas-/oil-fired
- Station produces equivalent of
  - 20% Massachusetts demand
  - 150% Rhode Island demand

Existing Cooling System



Existing Cooling System



Current Conditions

- Winter flounder and other groundfish at historically low levels
- Maximum intake flows & heat loads
  - Once-thru cooling (June thru September)
    - 1299 MGD
    - 13 TBTU
  - Piggyback cooling (October thru May -- winter flounder spawning)
    - 925 MGD
    - 29 TBTU
- NPDES Permit renewal pending
  - Draft Permit Determination issued July 2002

Cooling Alternatives Evaluated

- Existing once-thru with seasonal piggyback
- Enhanced Multi-Mode (EMM)
- Unit 3 closed cycle
- All units closed cycle
- Others

Enhanced Multi-Mode

- What are the goals of EMM?
- How does EMM work?
- What benefits are expected from EMM?
- How do EMM costs and benefits compare with other alternatives?

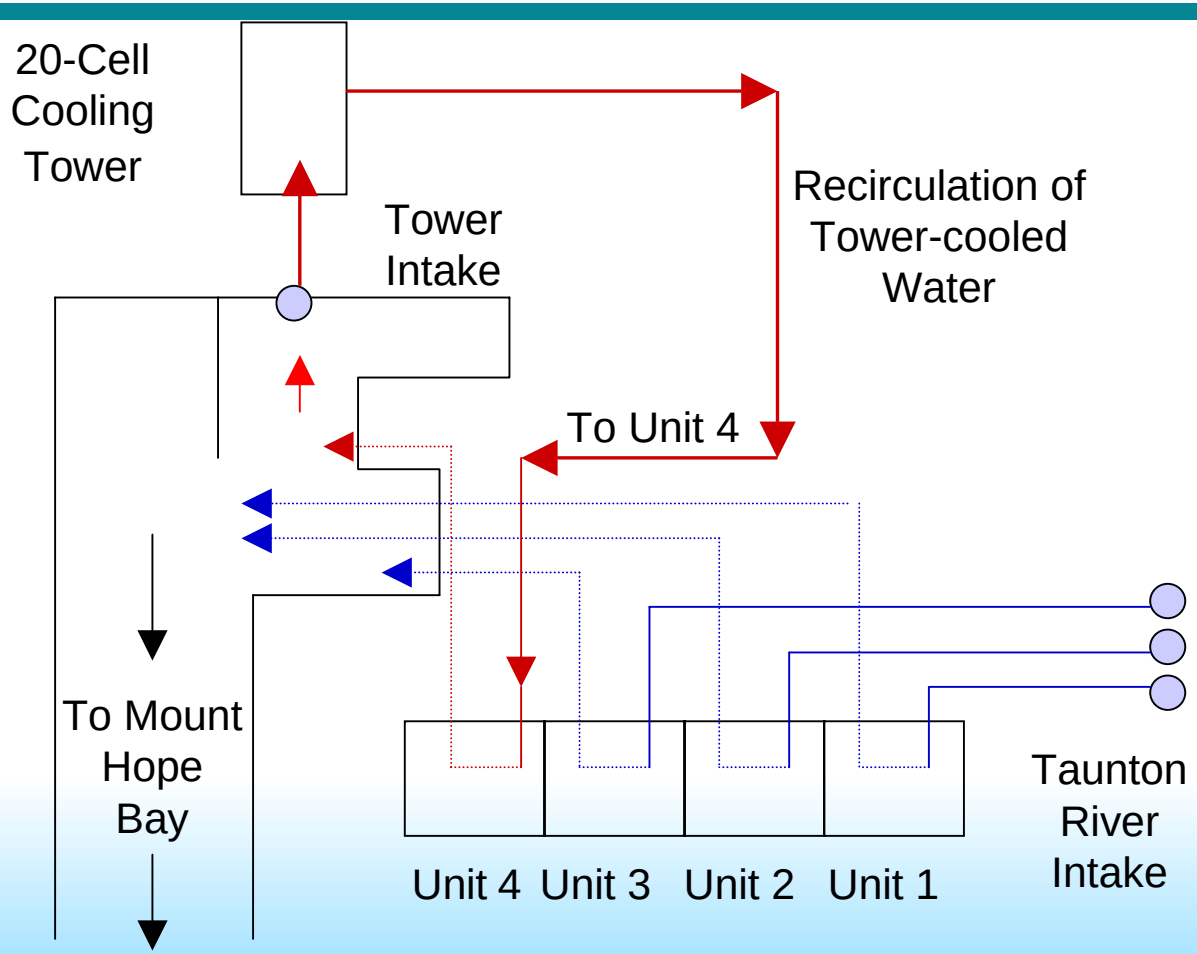
EMM Goals

- Reduce impingement/entrainment losses
  - by reducing intake flows
- Reduce already low discharge-related losses
  - by reducing heat load

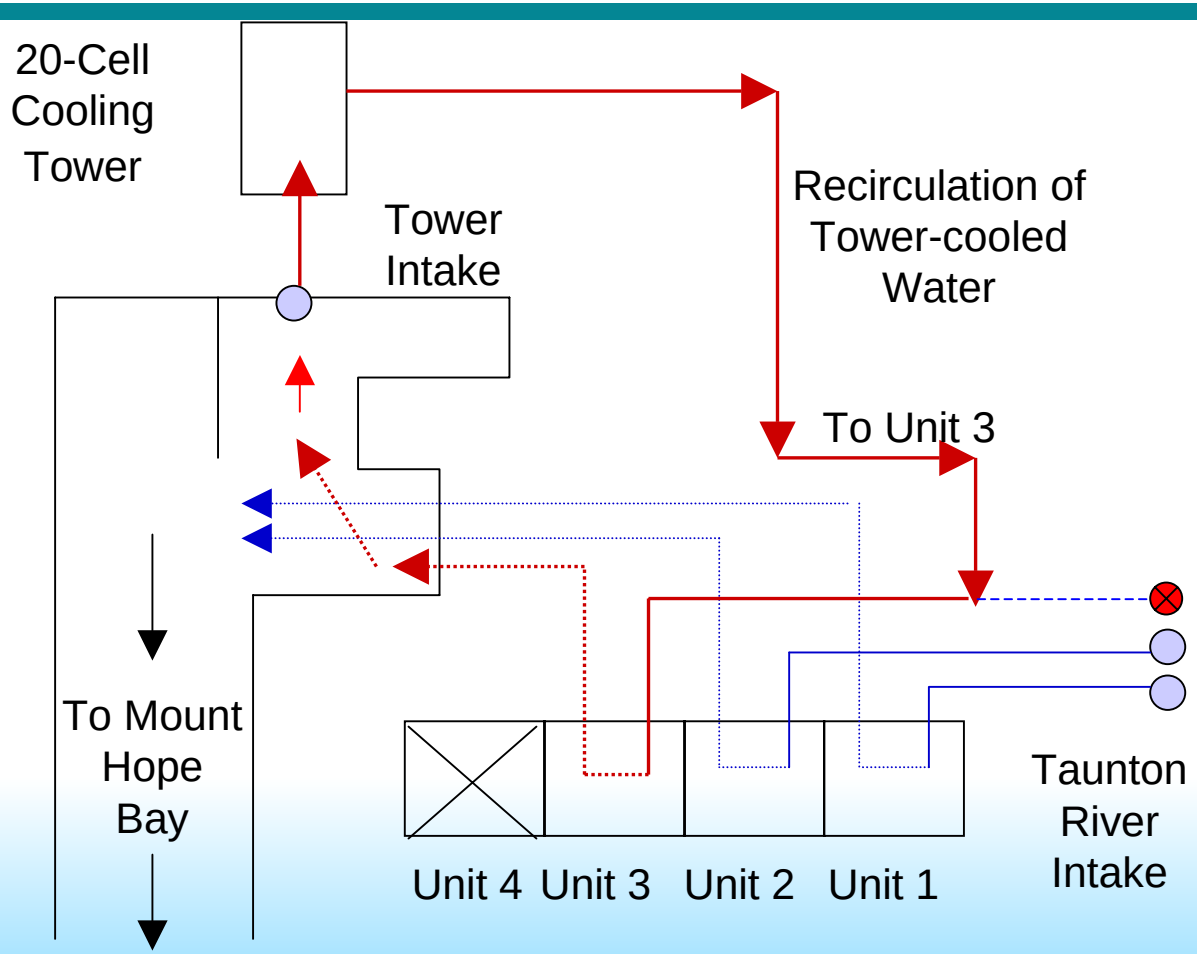
EMM Design

- Wet cooling tower
  - 20 cells
  - Mechanical draft, counter-flowing
  - Plume abatement
  - 14 trillion BTU per year total heat reduction
  - 327 MGD average annual flow reduction
- Flexible piping configuration for optimal plant operation

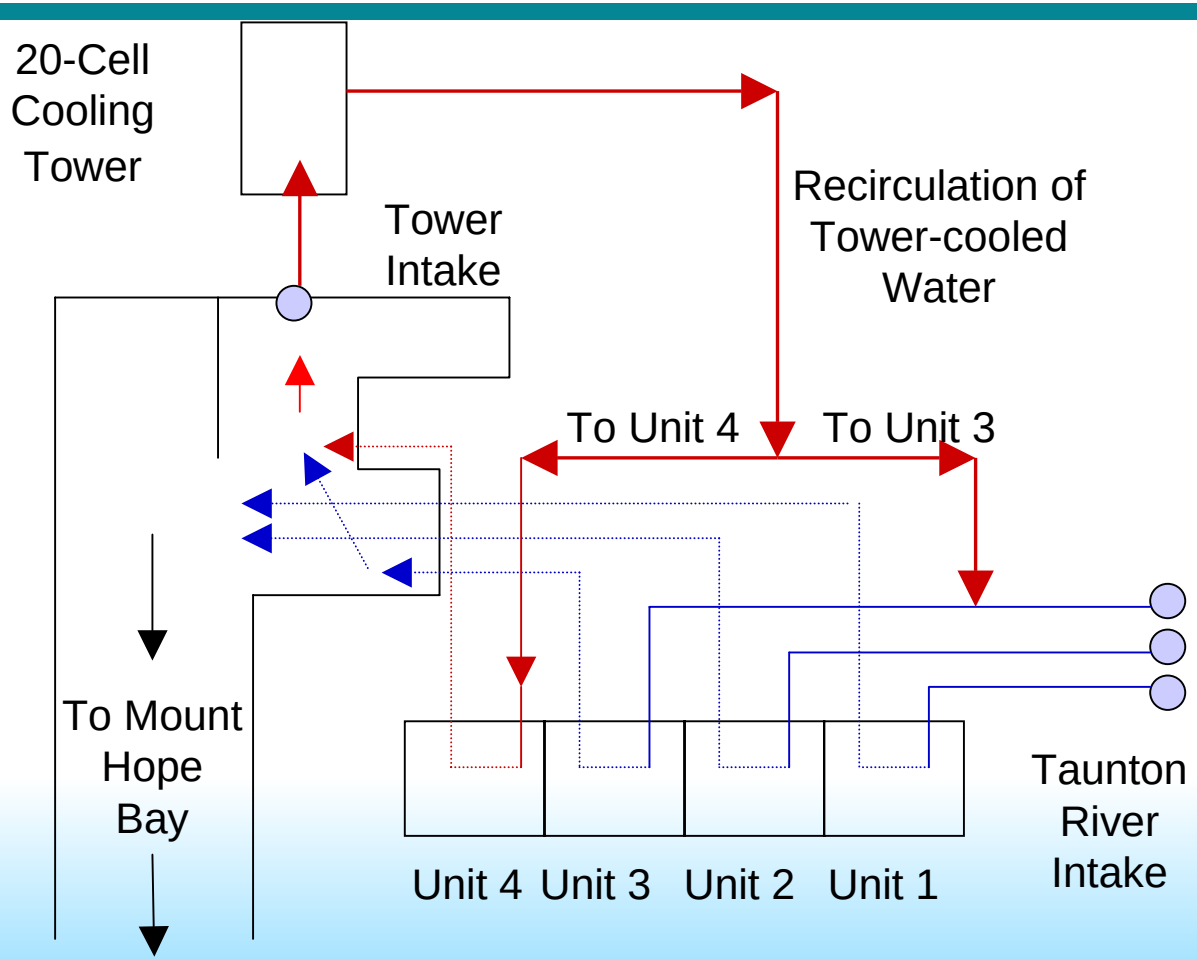
EMM – Unit 4 "Closed Cycle"



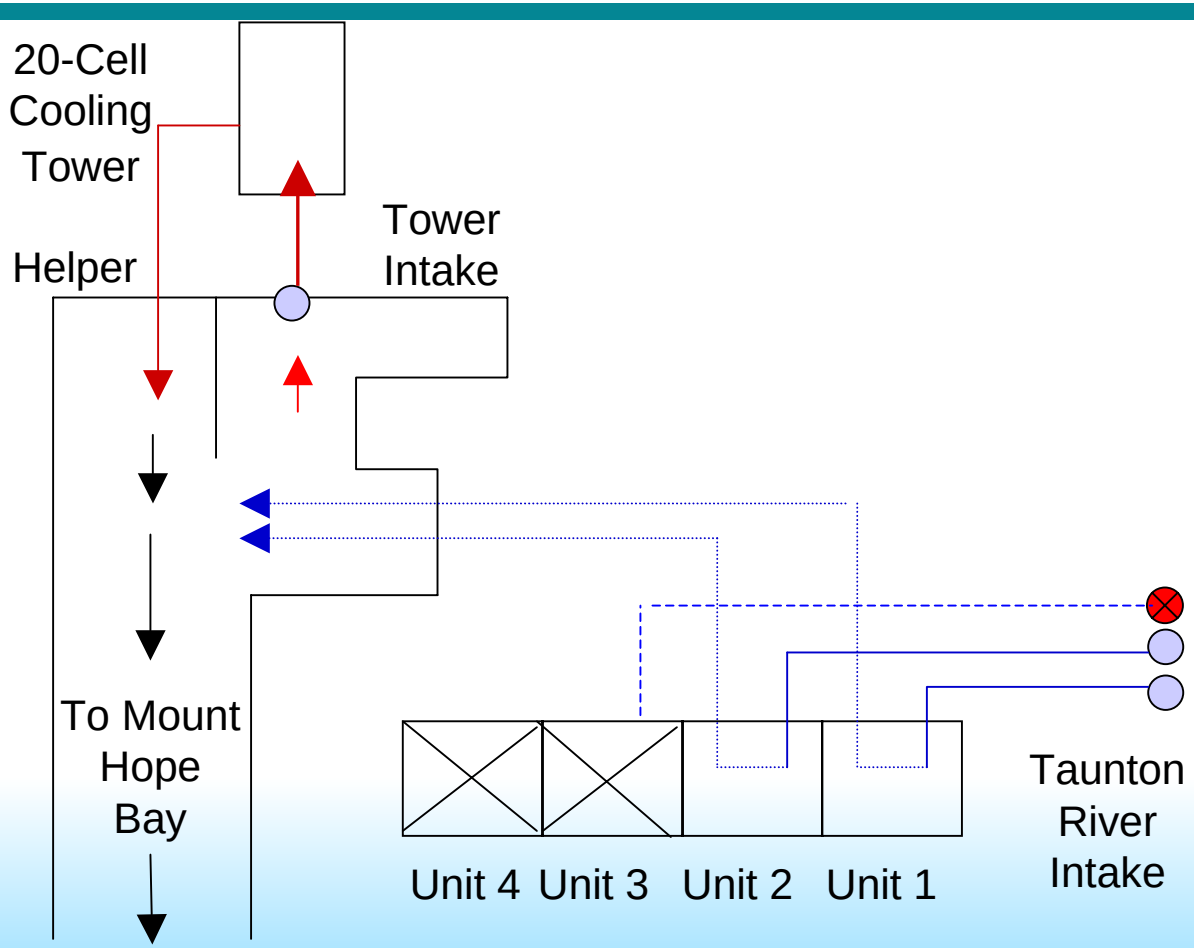
EMM – Unit 3 “Closed Cycle”



EMM – Unit 4 "Closed Cycle" & Unit 3 "Partial Closed Cycle"



EMM – Units 1 & 2 "Helper" Cooling



Other EMM Components

- Variable-Speed Drives on Units 1 & 2 circulating water pumps
- Installation of fish buckets on Units 1, 2 & 3 traveling screens

Flow & Heat Reductions

- Compared to existing once-thru with piggyback
  - 33% lower average annual flow
    - Existing – 977 MGD
    - EMM – 650 MGD
  - 33% lower annual heat load to Mount Hope Bay
    - Existing – 42 TBTU
    - EMM – 28 TBTU

Biological Benefits – *Reduced Intake Flow*

Species	Cause of Loss	Fishable Biomass Lost (lbs)			
		Existing Operation	EMM	Unit 3 Closed Cycle	All Units Closed Cycle
Winter Flounder	Entrainment	21,231	11,922	9,451	1,891
	Impingement	45	30	32	3
	Total E&I	21,276	11,952	9,483	1,894
Other Fished Species	Entrainment	23,027	13,229	14,032	1,328
	Impingement	149	105	110	12
	Total E&I	23,176	13,334	14,142	1,340
All Fished Species	Entrainment	44,258	25,151	23,483	3,219
	Impingement	194	135	142	15
	Total E&I	44,452	25,286	23,625	3,234

Biological Benefits – *Reduced Intake Flow*

- Reduction in impingement and entrainment

Species	Compared to Fishable Biomass Lost under Existing Operations		
	EMM	Unit 3 Closed Cycle	All Units Closed Cycle
Winter Flounder	44%	55%	91%
Other Fished Species	38%	36%	94%
All Fished Species	40%	43%	93%

Biological Benefits – *Reduced Heat Load*

- Analysis based on “reasonable worst-case” hydrothermal modeling of Mount Hope Bay
- Biothermal assessment of
  - Critical growth
  - Reproduction
  - Avoidance
  - Migratory blockage
  - Chronic thermal mortality
- ***Effects are negligible for all four alternatives, including Existing Operation***

Economic Evaluation

- Estimate future time path of costs & benefits
  - Identify significant differences in timing
- Express each year's costs & benefits in 2002$
- Compute cost-effectiveness ratio
- Compute cost-benefit ratio
- Apply EPA "wholly disproportionate" test

Cost-Effectiveness

- Focus on Flow Reduction
- Annualized Costs
  - 20 years plus construction period
- ***EMM most cost-effective***

Cooling-System Alternative	Annualized Cost (Millions of 2002 U.S. $)	Units of Flow Reduction (MGD)	Annualized Cost per MGD of Flow Reduction (Thousands of 2002 U.S. $)
EMM	6.9	327	21.1
Unit 3 Closed Cycle	13.0	323	40.1
All Units Closed Cycle	31.9	921	34.6

Cost-Benefit Ratio

- Total life-cycle costs and benefits
- Benefits due to:
  - Additional commercial fishery
  - Additional recreational fishery
- ***EMM lowest cost-benefit ratio***

Cooling-System Alternative	Fishery Benefit (Millions of 2002 U.S. $)	Technlogy Cost (Millions of 2002 U.S. $)	Cost:Benefit Ratio
EMM	0.20	50.69	253
Unit 3 Closed Cycle	0.23	95.31	412
All Units Closed Cycle	0.44	236.02	537

“Wholly Disproportionate” Test

- **Guideline: Costs not more than 10 times benefits**
- **None of the alternatives evaluated passes**
  - Costs range between 253 and 537 times benefits
  - EMM has lowest cost/benefit ratio

Conclusions

- Costs “wholly disproportionate”
- EMM clearly best of alternatives considered
  - Most cost-effective
  - Best cost-benefit ratio
- EMM achieves reductions by flexible, optimal use of closed-cycle cooling
- EMM readily adaptable to similar facilities

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